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Preliminary Geological Investigation of Dorothea and Sandra Townships: Evaluating Potential for Structurally Hosted Mesothermal Gold Mineralization

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Preliminary Geological Investigation of Dorothea and Sandra Townships: Evaluating Potential for Structurally Hosted Mesothermal Gold Mineralization

by

J.C. DeWolfe

2001

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Preliminary Geological Investigation of Dorothea and Sandra Townships: Evaluating Potential for Structurally Hosted Mesothermal Gold Mineralization

J.C. DeWolfe[1]
Ontario Geological Survey
Open File Report 6059
2001

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[1] Student, Department of Earth Sciences, Laurentian University, 935 Ramsey Lake Road, Sudbury, Ontario, Canada, P3E 2C6

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Introduction

LOCATION

Dorothea and Sandra townships are located in northwestern Ontario, approximately 7 km north of the town of Beardmore (Figures 1 and 2). Geologically, Dorothea and Sandra townships occupy the western end of the Beardmore–Geraldton Belt (BGB) of the Archean Superior Province. The study area (Figure 3) is bounded to the south by the southern limits of Dorothea and Sandra townships, to the west by the shore of Lake Nipigon, and to the north and east by the southern contact of the Proterozoic diabase intrusion. Much of the study area is accessible via a network of logging roads and trails branching off Camp 72 Road (*see* Figure 2). Camp 72 Road is a secondary gravel road that is accessed from secondary Highway 580, 5.2 km from Highway 11. The western end of the study area is accessible by boat from Lake Nipigon. The interior of the area can also be accessed by small boat via the Namewaminikan (Sturgeon) River. Only a few small lakes are present within the study area, most of which are connected by trails. A powerline right-of-way, serving a hydro-electric dam on the Namewaminikan (Sturgeon) River, transects the southeastern portion of the area. Presently, a large part of the study area is easily accessible by foot as much of the forest was destroyed by a large fire in the spring of 1998.

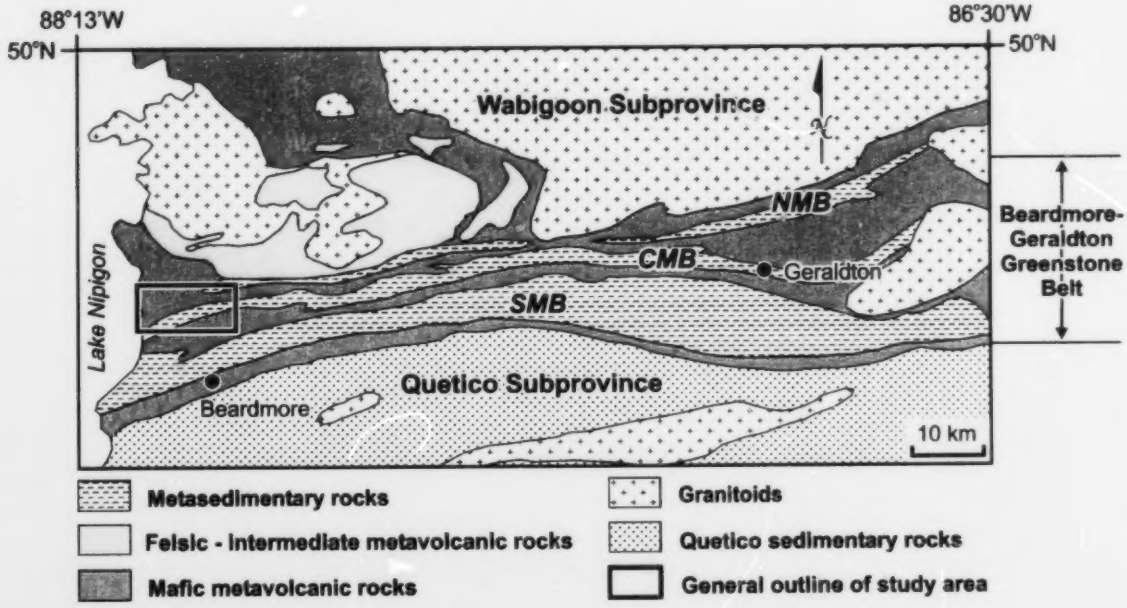


Figure 1. Location map for the Beardmore–Geraldton Belt (BGB); the study area is outlined by a black box. *Modified from* Williams (1990).

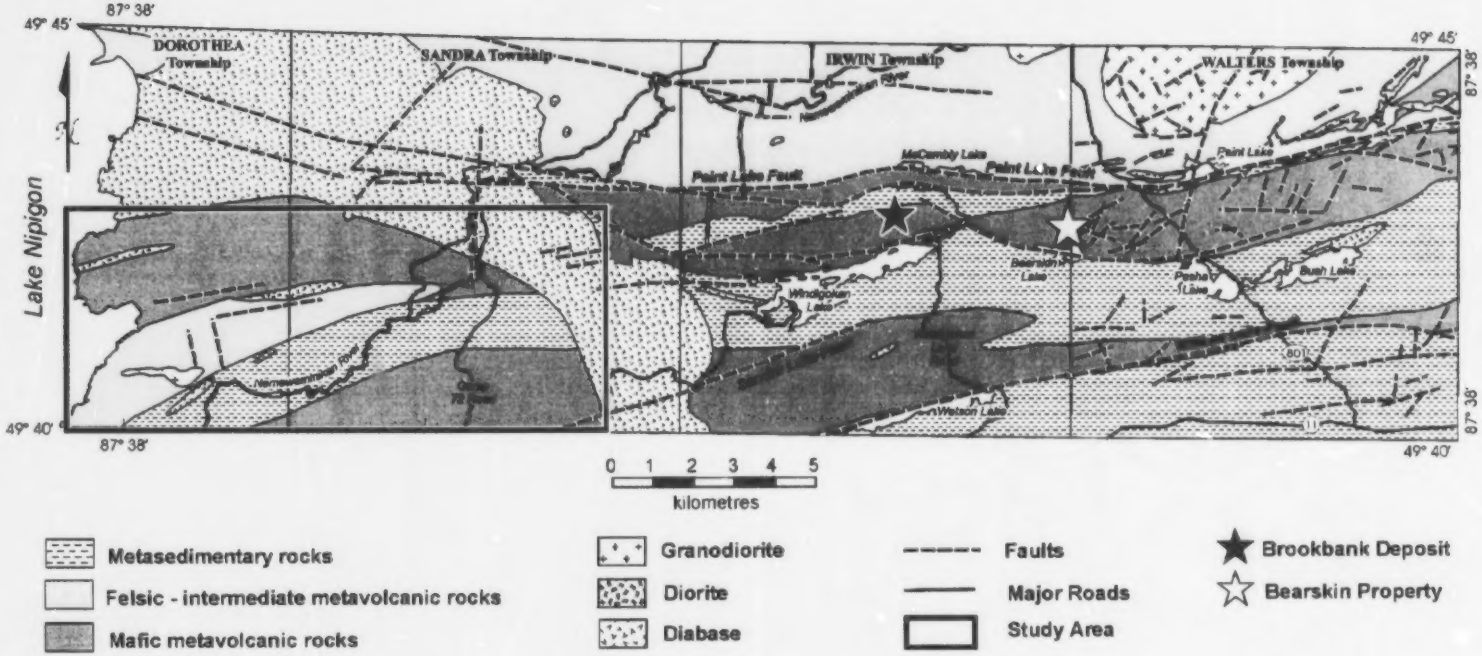


Figure 2. General geology map of the western Beardmore–Geraldton Belt (BGB), comprising Dorothea, Sandra, Irwin, and Walters townships. Note that the study area is outlined by a black box. *Modified from* Mackasey (1975, 1976).

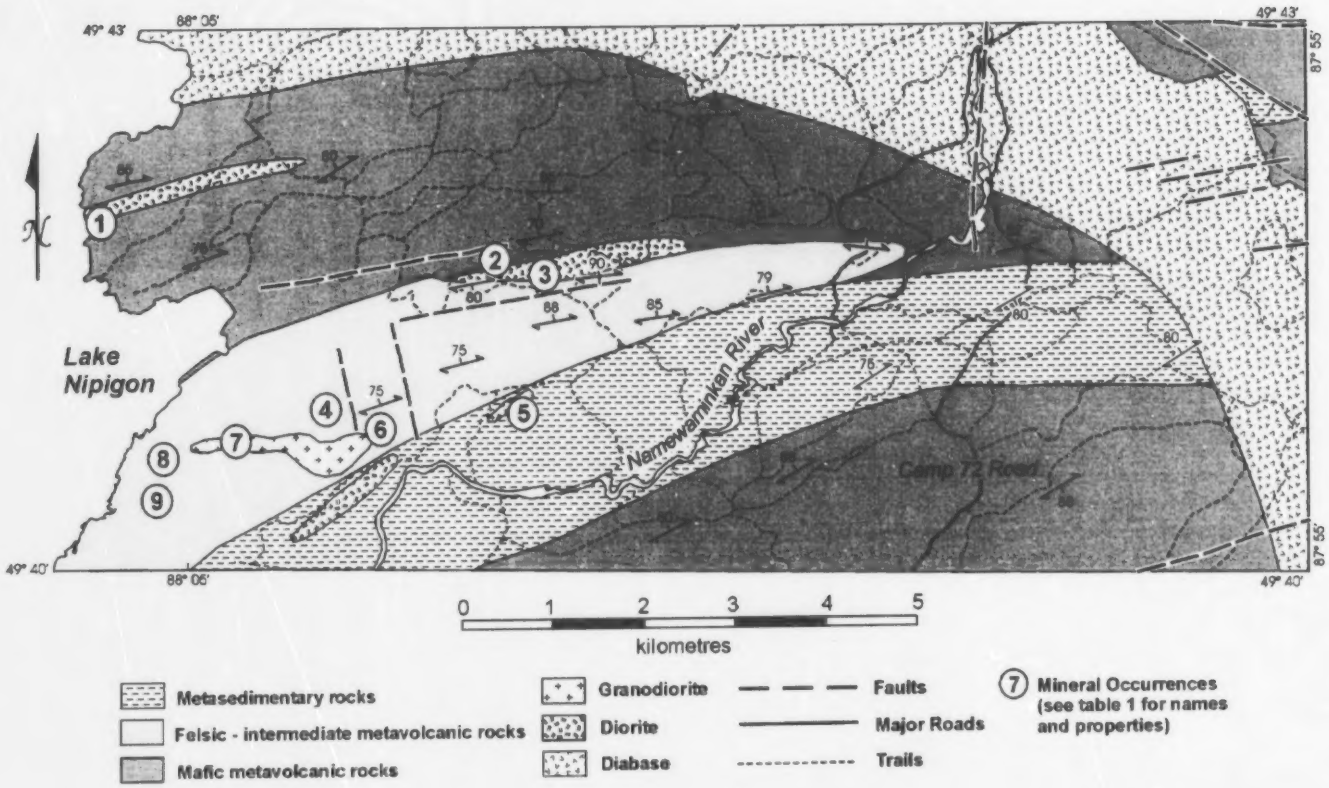


Figure 3. Detailed geology map of study area within Dorothea and Sandra townships. For details of mineral occurrences (circled numbers), *see* Table 1. *Modified from* Mackasey (1975).

PURPOSE

Mesothermal gold occurrences hosted by regional brittle–ductile deformation zones occur throughout the Beardmore–Geraldton Belt. Exploration programs for gold are currently underway immediately east of the study area in Irwin Township (Brookbank and Foxear properties of Ontex Resources Ltd.) and Walters Township (Bearskin property of St Anthony Resources) (*see* Figure 2). The purpose of this study is to investigate Dorothea and Sandra townships for potential mesothermal gold mineralization similar to that found in Irwin and Walters townships. Emphasis is placed on 1) assessing the nature and distribution of deformational features within the study area, 2) determining their relationship to regional deformation zones, and 3) assessing the potential of the structures as hosts for mesothermal gold mineralization. This report combines observations collected in the study area during a one-week reconnaissance mapping project, completed during the fall of 2000, with regional observations gathered from remote sensing and geophysical data. Comparison of the key geological features of the area will be made with those observed by the author in areas of known mesothermal gold mineralization in the Irwin and Walters townships during field mapping for an MSc thesis at Laurentian University in conjunction with the Ontario Geological Survey.

TOPOGRAPHY

Exposure within the study area is poor, as the topography is generally flat lying, with much of the area covered by glacial sands and shallow marshes. The area comprises a sequence of felsic to mafic metavolcanic and metasedimentary belts with associated minor felsic to mafic intrusions (*see* "Geology" for detailed description of lithologies). Outcrops within the metasedimentary and mafic metavolcanic belts generally form discontinuous, northeast-trending ridges, which trend northward within the felsic to

Table 1. Compilation of mineral occurrences of the study area. Information gathered from Ministry of Northern Development and Mines' ERLIS (Earth Resources and Land Information System) Mineral Deposit Inventory (MDI), Mason and White (1986) and Mackasey (1975). Deposit names in brackets represent previous names.

Number	Deposit Name	MDI Number	Principal Commodity
1	Bish Bay (*Kimberly Copper*)	MDI-52H09NE-00007	asbestos
2	Amorada North (*Nortoba; Tyson, V.W.; Woods-Tyson*)	MDI-52H09NE-00007	gold, silver
3	Amorada (*Amorada South; Nortoba; Tyson Prospect; Tyson A.E.*)	MDI-52H09NE-00007	gold, molybdenite
4	Lawrence-McKirdy	MDI-52H09NE-00007	gold, copper, molybdenite
5	Craig, C.L.	MDI-52H09NE-00007	iron
6	Montmorr 3	MDI-52H09NE-00007	gold, copper, molybdenite
7	Hopkins, A.P.E.	MDI-52H09NE-00007	gold, copper, molybdenite
8	Johnson, T. (*Renshaw, Z.*)	MDI-52H09NE-00007	gold, copper, molybdenite
9	Montmorr 1 (*Northwind*)	MDI-52H09NE-00007	gold

intermediate metavolcanic belt. The felsic to mafic intrusions form elongate bodies trending to the northeast. Exposure is almost continuous along the shore of Lake Nipigon, but is limited along the Namewaminikan River, occurring for the most part in a series of rapids and small falls. Complementing the natural outcrop are a number of trenches and small quarries from past prospecting activity (*see* Figure 3 and Table 1 for compilation of mineral occurrences).

Geology

GENERAL GEOLOGY

The Beardmore–Geraldton Belt (BGB) (*see* Figure 1) forms a transitional zone between the Wabigoon Subprovince to the north, and the Quetico Subprovince to the south (Williams and Stott 1991). The Beardmore–Geraldton Belt consists of 3 distinct east-trending, steeply dipping metasedimentary belts: the northern, central and southern belts (*see* Figure 2) (Mackasey 1975, 1976). The metasedimentary belts are separated by felsic to mafic metavolcanic belts. The geology of the study area (*see* Figure 3) consists of the central metasedimentary belt, bounded to the south by a mafic metavolcanic belt, and to the north by both mafic and felsic to intermediate metavolcanic belts. Near the westernmost end of the Beardmore–Geraldton Belt, the belts are cut by a large Proterozoic diabase intrusion (Mackasey 1975, 1976). The boundaries between the metasedimentary and metavolcanic belts are commonly marked by regional brittle–ductile deformation zones. Mesothermal gold occurrences hosted by these deformation zones have produced in excess of 4.1 million ounces of gold from over 250 occurrences since the early 1900s (Mason and White 1986). Currently, there are no producing mines in the BGB; however, a number of prospecting and exploration projects are underway that focus on shear-hosted mesothermal gold.

LITHOLOGIES

Metasedimentary Rocks

The central metasedimentary belt in the study area consists primarily of polymictic conglomerate, with minor sandstone and banded iron formation limited to a few isolated outcrops.

The polymictic conglomerate (Photo 1a) is clast supported, consisting of poorly sorted pebble to cobble sized clasts. The conglomerate is dominated by felsic to intermediate volcanic clasts and felsic intrusive clasts, with lesser amounts of mafic volcanic and sedimentary clasts. The conglomerate matrix is composed of a fine- to medium-grained, grey-green wacke. Few outcrops show primary sedimentary structures, with the exception of localized occurrences of gradded bedding with tops facing to the north. The matrix of the wacke is weak to moderately foliated with a steeply dipping, east-trending cleavage. The clasts appear weakly deformed to undeformed.

Grey-green, fine- to medium-grained wacke is observed in several locations. It is similar in appearance to the matrix of the polymictic conglomerate and, in several locations, it progressively changes through a pebble-rich sandstone into conglomerate (*see* Photo 1a). The sandstone also displays a weak to moderately developed, steeply dipping, east-trending cleavage.

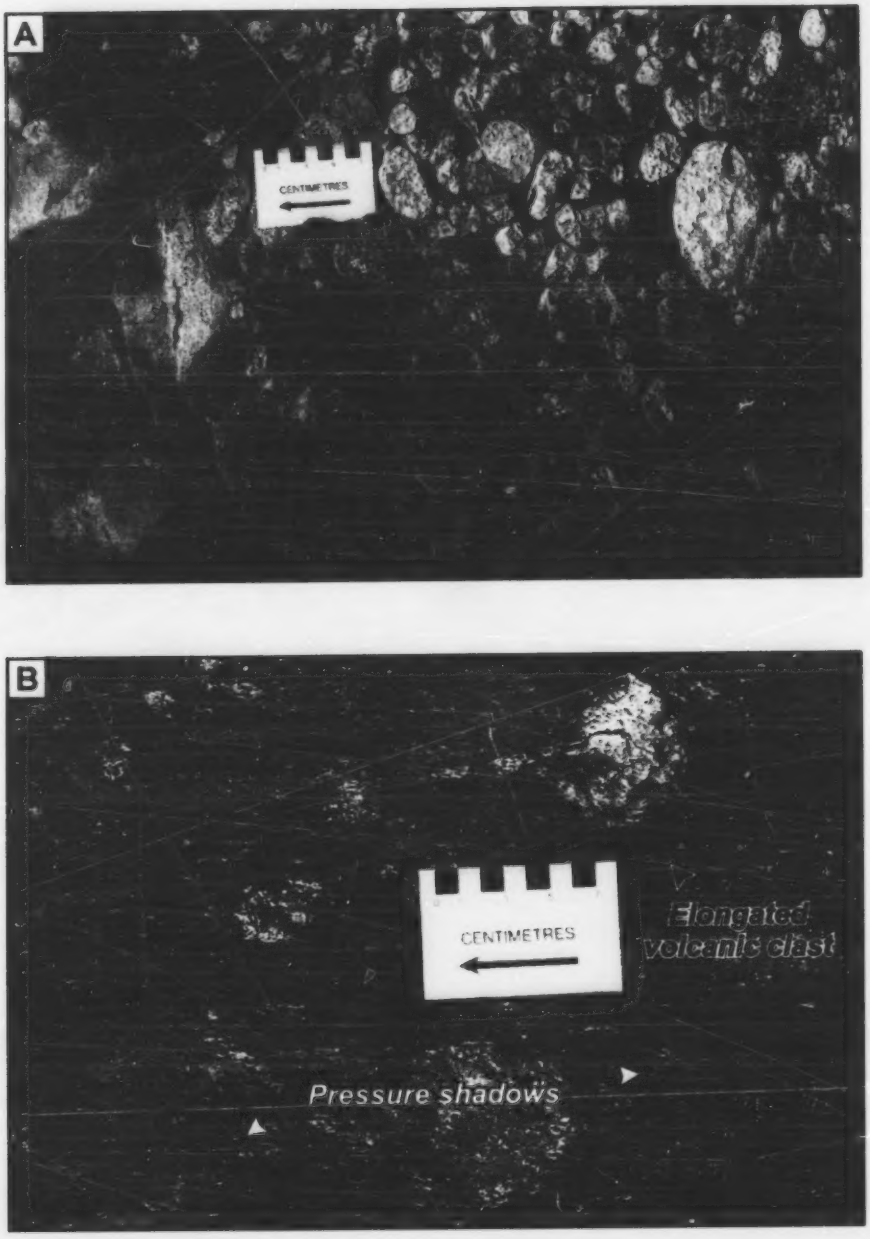


Photo 1. a) Photo of undeformed polymictic conglomerate of the central metasedimentary belt (*see* Figure 3). Granitic clasts are white, whereas intermediate to mafic volcanic clasts are dark grey. Note gradation from conglomerate into pebbly sandstone toward the left side of photo. Photo facing east; card for scale. b) Photo of asymmetrical pressure shadows, indicative of dextral deformation, formed on granitic clasts in polymictic conglomerate from Irwin Township (*see* Figure 2). Note strong stretching and foliation of intermediate to mafic volcanic clasts (dark grey in colour). Photo facing south: card for scale.

Banded iron formation (BIF) (Photo 2) is finely layered with 0.5 to 3 cm thick maroon and pale green cherty layers and only minor thin layers of hematite and magnetite. Bedding in the BIF dips moderately to the north. The BIF is largely undeformed, with a few localized occurrences of S-kink folds (Figure 4; *see* Photo 2).

Mafic Metavolcanic Rocks

The mafic metavolcanic rocks occur in two distinct belts in the study area (*see* Figure 3). The belts are typically composed of fine- to medium-grained, black-green massive basalt flows with localized pillowed and amygdaloidal horizons. The massive basalt flows are typically weakly foliated with the same east-trending cleavage observed in the metasedimentary rocks.

Felsic to Intermediate Metavolcanic Rocks

Felsic to intermediate metavolcanic rocks within the study area (*see* Figure 3) are predominantly volcaniclastic. Massive units of medium-grained, pale grey-green tuff are most abundant, with lesser amounts of tuff breccia composed of small, 1 to 3 cm sized fragments. Weak to moderate east-trending cleavage is also observed in most of the tuffs.

Felsic to Mafic Intrusions

Several small intrusions ranging in composition from granodiorite to diorite (*see* Figure 3) cut the metavolcanic and metasedimentary rocks near the western end of the study area. The intrusions are medium to coarse grained, often with quartz and feldspar phenocrysts. Zones of intense epidote alteration and minor molybdenite mineralization were observed in both the intrusions and wall rock in several locations.

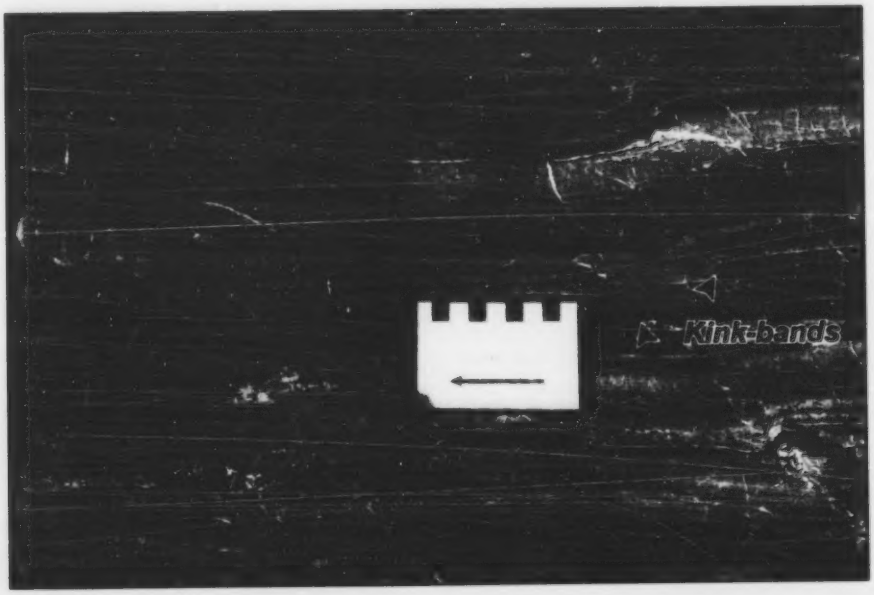


Photo 2. Photo of banded iron formation (BIF) of the central metasedimentary belt (*see* Figure 3), Dorothea Township. Regional cleavage is subparallel (slightly counterclockwise) to layering in the BIF. S-kink folds with northwest-trending kink bands can be

Structure

The dominant structure observed in the study area is a west-trending, steeply dipping to vertical cleavage (Figure 5a). Associated with the cleavage is a weak slickenside lineation that plunges moderately to the northwest. The cleavage is slightly counterclockwise to primary layering and is consistent with development by dextral shearing along an east-trending regional deformation zone. Intensity of the cleavage ranges from weak to moderate across the study area, with zones of strong to intense cleavage localized within a number of shear zones. The shear zones are typically less than several metres in width, but zones up to 8 m wide are observed in several locations (Photo 3a). Deformation within the shear zones consists of an intensification of the regional cleavage and is characterized by the development of a shear foliation (Photo 3b). Intensity of deformation diminishes rapidly outside of the shear zones to produce a relatively sharp contact with the less deformed rocks. The shear zones are commonly marked by a rusty brown colour, resulting from strong to intense ankerite (iron-carbonate) alteration. Associated with the ankerite alteration are lesser amounts of chlorite, epidote and quartz alteration. The orientation and appearance of the shear zones are consistent with those observed in Irwin and Walters townships (*see* Figures 5a, 5b and 5c) and, in particular, they exhibit many of the features observed in the mineralized shear zones. Although pervasive potassic alteration, characterized by pink potassium feldspar or sericite,

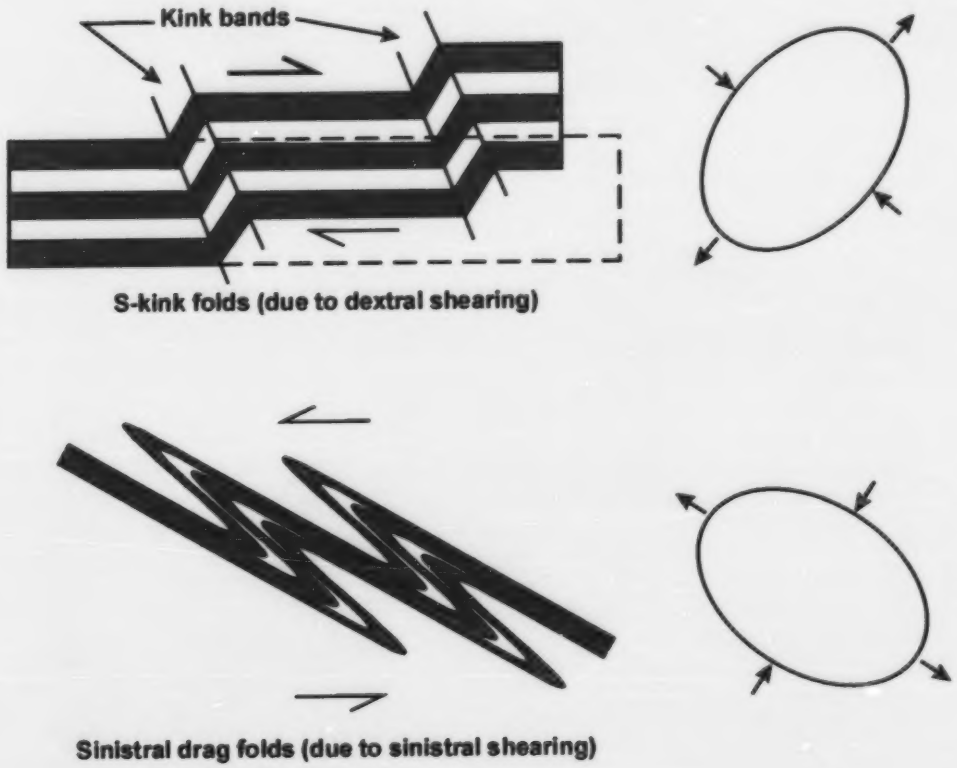


Figure 4. Schematic diagram illustrating the different processes responsible for the formation of S-kink folds versus asymmetrical sinistral drag folds (S-folds). Ellipses represent orientation of the finite strain ellipse, with arrows indicating the orientation of axes of maximum stretching and maximum shortening. *Modified from* Davis and Reynolds (1996); Pfaff and Johnson (1989).

appears to be spatially associated with elevated gold values in several of the shear zones of Irwin and Walters townships, the potassic alteration appears to be absent within the shear zones of the study area. Petrographic and geochemical analyses are needed to determine if potassic alteration mineral assemblages are present within the shear zones of the study area, even if in much lower concentrations, or overprinted by subsequent alteration events.

S-kink folds (*see* Photo 2), with fold axis plunging moderately to the northwest, occur within BIF of the central metasedimentary belt. Kink bands trend toward the northwest, and are oriented approximately 60° clockwise from the general trend of the cleavage. Sinistral offsets, generally with less than several centimetres in displacement, are observed along several of the kink band boundaries (*see* Photo 2). Deformational processes responsible for forming kink bands in shear zones are different than those responsible for asymmetric drag folds (*see* Figure 4) in that S-kink folds are a product of dextral shear, whereas asymmetric S-folds form during sinistral shear (Davis and Reynolds 1996, p.411).

Exposures of lithologic contacts within the study area are rare, but, where observed, the contacts appear undeformed relative to lithologic contacts in Irwin and Walters townships, the majority of which are marked by map-scale brittle–ductile faults and shear zones. The few map-scale faults and shear zones observed in the study area occur within the belts rather than at their contacts, but share the same general easterly trend as those present in Irwin and Walters townships. The lack of abundant map-scale deformational features within the study area is probably due, in large part, to the poor exposure throughout the belts, particularly near the contacts with adjacent units. Outcrops are much more abundant throughout much of Irwin and Walters townships. Strong deformation along the boundaries could potentially be responsible for the lack of exposure within the study area, as the strongly deformed rocks could be more susceptible to weathering and erosion. Conversely, the more obvious case exists where the contacts may simply be undeformed within the study area, since not all contacts in Irwin and Walters townships are marked by the brittle–ductile deformation zones. Detailed studies aimed at observing significant increases in intensity of deformation proximal to unexposed contacts should determine if the contacts are deformed as well as their potential for hosting gold mineralization. These deformed contacts are of interest as the majority of mineral occurrences in Irwin and Walters townships are hosted by shear zones along lithologic contacts, or in splays branching off from these shear zones.

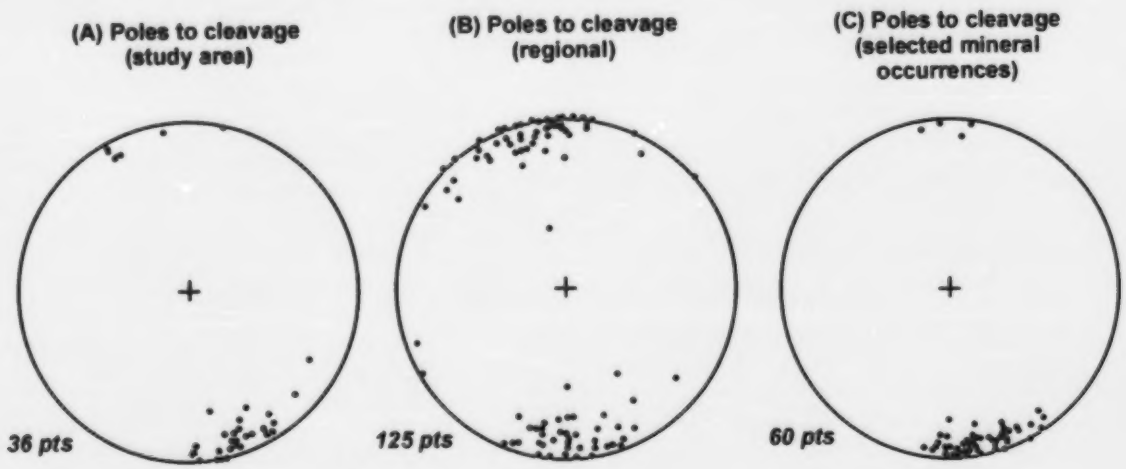
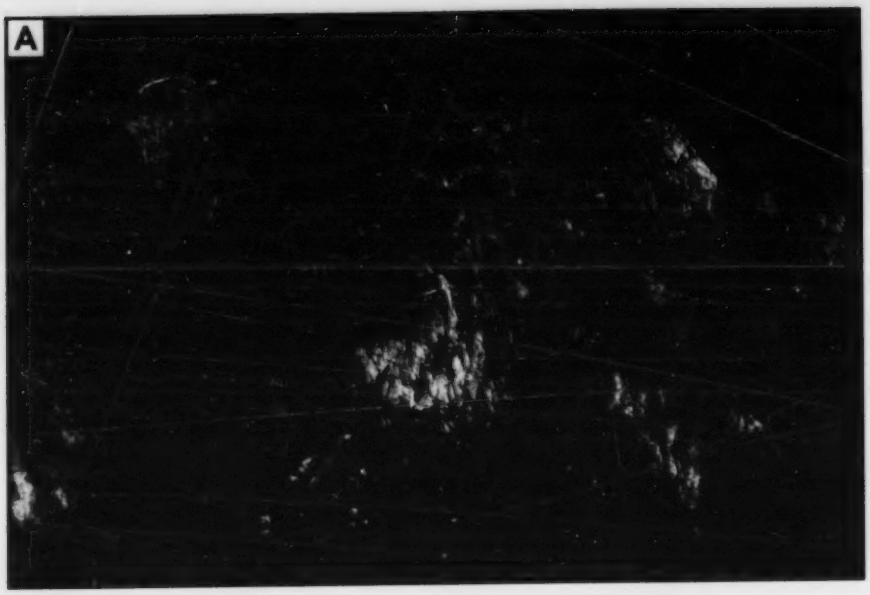

(A) Poles to cleavage (study area)
(B) Poles to cleavage (regional)
(C) Poles to cleavage (selected mineral occurrences)
36 pts
125 pts
60 pts

Figure 5. Stereographic projections (Schmidt net, lower hemisphere) of poles to cleavage from: a) the study area; b) the regional study of Irwin and Walters townships; and c) select mineral occurrences within Irwin and Walters townships.



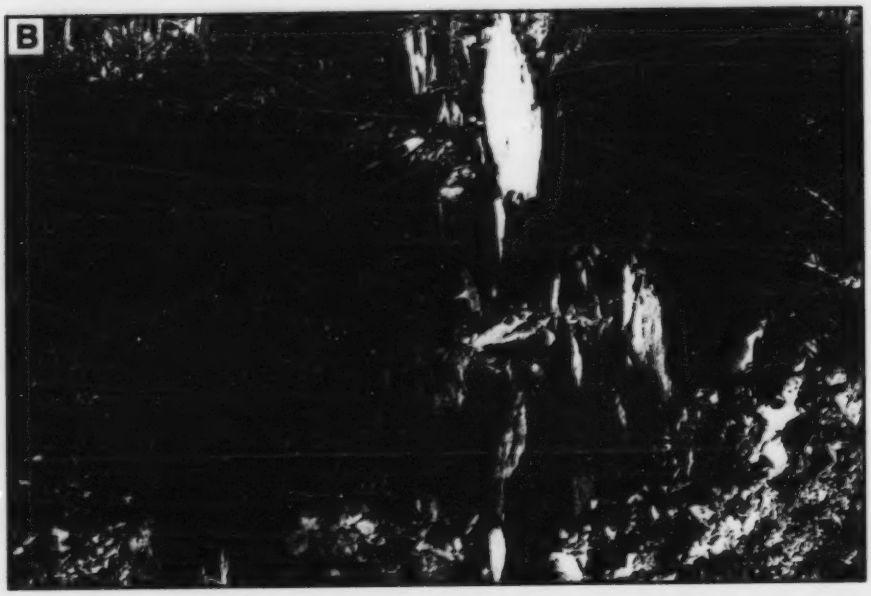


Photo 3. a) Photo of 8 m wide shear zone in mafic metavolcanic rocks, Sandra Township. Photo facing east; hammer for scale. b) Photo of strong to intense cleavage resulting in development of shear foliation within shear zone in mafic metavolcanic rocks, Sandra Township. Photo facing west; hammer for scale.

Based on the nature and distribution of structures observed, the rocks of the study area appear to have undergone at least part of the same progressive dextral deformation responsible for producing the shear zones and faults observed in Irwin and Walters townships (DeWolfe, Lafrance and Stott 2000). The orientation of the cleavage within the study area is consistent with the regional easterly trend for cleavage throughout the belt (*see* Figures 5a, 5b and 5c). Map-scale and outcrop-scale deformational features and shear sense indicators are more abundant to the east of the study area, in Irwin and Walters townships. Deformation also appears to be more intense to the east, but, as previously mentioned, this may be due, in part, to the poor exposure within the study area. However, there is also evidence that the region has undergone heterogeneous deformation, as many of the strongly deformed units in Irwin and Walters townships display abundant well-developed deformational features, whereas the same units within the study area are less deformed and do not exhibit many of these features. An example of this can be seen in the polymictic conglomerate, where granitic clasts in conglomerate from Irwin and Walters townships commonly display well-developed dextral shear sense indicators, such as asymmetrical pressure shadows (tails) and back-rotated clasts, and less competent volcanic clasts are typically highly elongated parallel to the direction of shearing (Photo 1b). Polymictic conglomerate within the study area appears relatively undeformed, with only weak elongation of some of the volcanic clasts, and a weak cleavage in the matrix (*see* Photo 1a). Other shear sense indicators, including S- and Z-kink folds, sinistral and dextral asymmetrical drag-folds, several generations of cleavage, and folded and boudinaged quartz veins, are abundant within Irwin and Walters townships, while only a few isolated occurrences of S-kink folds were observed within the study area.

Geophysics and Remote Sensing

Airborne geophysical maps produced by the Ontario Geological Survey (OGS 1998) were combined with OGS digital topographic maps (DTM) to better interpret the regional distribution of deformation zones in and around the study area.

The airborne magnetic map (Figure 6a) provides a general outline for several of the belts and some of the regional structures within the western end of the Beardmore–Geraldton Belt. The diabase intrusion is marked by a strong negative anomaly, which appears to interfere with the magnetic expression of many of the units within the study area as the diabase dips to the west. Several of the basalt flows within the mafic metavolcanic belts and BIF within the metasedimentary rocks display strong positive anomalies. Unfortunately, many of the basalt flows have low magnetic intensities, which makes distinguishing them from adjacent felsic to intermediate metavolcanic rocks and metasedimentary rocks, particularly those containing BIF, on the basis of magnetic intensity very difficult. Several of the regional deformation zones, including the Paint Lake deformation zone, which passes to the north of the study area (*see* Figures 6a and 2), can be observed cutting across the diabase intrusion.

The majority of lithologic contacts and deformational zones throughout the belt are well delineated on the resistivity map (Figure 6b). Observations of the regional deformation zones of the western Beardmore–Geraldton Belt are consistent with those made from the magnetic map, in that the major deformation zones cut across the diabase intrusion, and pass immediately to the north (Paint Lake deformation zone) and south (Sandra Lake fault) of the study area. Unfortunately, the lineaments produced by the resistivity anomalies are better developed outside of the study area, so they do not provide a great deal of insight into the presence of any regional-scale deformational zones within the study area.

The DTM (Figure 6c) improves on the resistivity map (*see* Figure 6b) in that the lithological and deformational boundaries are much sharper. Again, the regional deformational zones can be observed

passing immediately to the north and south of the study area, while there is no strong evidence for their presence within the study area. However, recognition of lineaments on the DTM is hampered within a large part of the study area by thick glacial overburden, which creates a smoothing effect on the topography.

Conclusions

Based on observations combined from field work, remote sensing and geophysical maps, there is no definite proof that any of the regional deformational zones present in Irwin and Walters townships project into the study area. However, there is enough evidence present within the study area to indicate that their presence cannot be ruled out completely. The rocks of the study area display structures interpreted to represent the same episode of progressive dextral deformation that is observed in Irwin and Walters townships, although the intensity of deformation is less within the study area. The presence of several regional deformation zones passing immediately to the north and south of the study area improves the potential for mesothermal gold mineralization within the study area. Both the Brookbank and Bearskin properties, two of the notable mineralized occurrences to the immediate east of the study area, appear to occur along splays branching off of the main Paint Lake deformation zone (*see* Figure 6c). The presence of shear zones, some exceeding several metres in width and displaying alteration mineral assemblages similar to those observed at known mineral occurrences within Irwin and Walters townships, might be potential splays branching off the main deformation zones.

Deformation-hosted mineralization aside, most of the sulphide mineralization within the western half of the study area is associated with granodiorite and diorite intrusions. It is also clear from the compilation of mineral occurrences (*see* Figure 3 and Table 1) that many of the occurrences within the study area are spatially associated with these intrusions. The intrusions are rather small, but the potential exists for disseminated porphyry-type gold mineralization.

Further mapping is warranted to better delineate the known shear zones and to discover additional shear zones. The focus should not be limited to large regional-scale deformation zones, since fault splays clearly play an important role in gold mineralization within the Beardmore–Geraldton Belt. The forest fire that affected much of the study area should provide access to new outcrops and shear zones previously covered by the dense forest. Field work should also be augmented by petrographic and geochemical studies to better understand the relationships between the structures, alteration zones and mineralization. Understanding these relationships is necessary for evaluating the potential for mesothermal gold mineralization in the study area.

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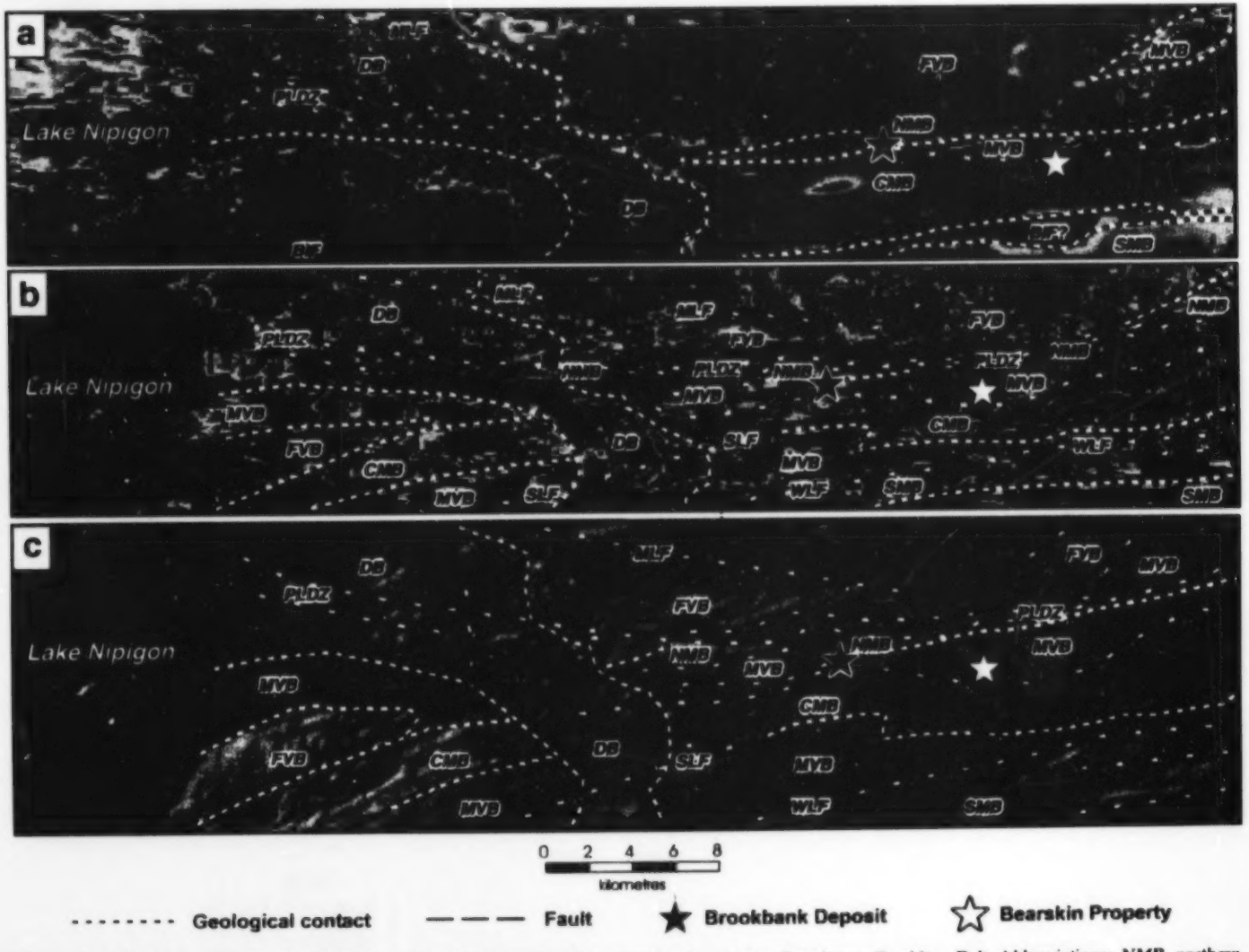

Figure 6. a) Airborne magnetic, b) resistivity, and c) digital topographic maps for the western Beardmore-Geraldton Belt. Abbreviations: ***NMB***, northern metasedimentary belt; ***CMB***, central metasedimentary belt; ***SMB***, southern metasedimentary belt; ***FVB***, felsic to intermediate metavolcanic belt; ***MVB***, mafic metavolcanic belt; ***DB***, diabase intrusion, ***BIF***, banded iron formation; ***PLDZ***, Paint Lake deformation zone; ***SLF***, Sandra Lake fault; ***WLF***, Watson Lake fault; ***MLF***, Musca Lake fault.

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Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.